

Remote-Site Ambient Ozone Data Summary, 2023

Regions 2 and 4, US Forest Service

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Fort Robinson, Soldier Creek Wilderness, Nebraska National Forest

Executive Summary:

- Surface ozone continued a general downward trend since peaking in the wildfire-influenced years of 2020-2021. Greatest impacts in 2023 were mostly restricted to areas subject to urban-source pollutants.
- The Uintah Basin, after several years of more modest ozone observations, experienced very high levels of surface ozone in early 2023.
- Front Range and Wasatch Front forests continue to be at risk for foliar damage and growth constraint, with risk particularly acute for quaking aspen. These areas have consistently experienced ozone exceeding the NAAQS since the inception of monitoring. Not all of the sites experiencing high ozone are within the EPA's current ozone nonattainment areas.
- One site (Fort Robinson, Nebraska NF) was rehabilitated and put back into service in late summer 2023. Another site, Hebron Slough (North Park, CO) was taken out of service. A BLM multi-pollutant facility began operation nearby, and duplicate data were judged to be unnecessary.

I. Changes in the Regulatory Environment

Since the inclusion of all of Weld County, Colorado in the Front Range EPA ozone nonattainment area (EPA 2021), no changes have been made to the regulatory status of any lands within the R2/R4 network footprint.

EPA is planning a review of the current ozone NAAQS (70 ppb, both primary and secondary) and published an outreach notice (EPA 2023a) in August. The intention of this event is to assess current/emerging science and determine whether revising the 70 ppb standard downward is advisable. The workshop is planned to convene sometime in the spring of 2024.

In February 2023, EPA published a review of their dry deposition and ozone monitoring network (CASTNet) (EPA 2023b). CASTNet sites collect high-quality, year-round ozone data at 90+ sites nationwide. Data from several of these sites are incorporated into RMRS's annual analyses and reports. In reduced-budget scenarios, EPA proposed reducing the part of the network with ozone data collection to 30-50 sites. The report did not detail which sites would be likely to be decommissioned in the event of budget cuts. However, RMRS-operated CASTNet site CNT169 (Centennial, WY) is one of the most expensive sites to operate. RMRS staff and national-level USFS Air Resource Management staff spent time in 2023 documenting data availability, data utility, and costs associated with operating the site. No decisions have been made with respect to continued operation of any CASTNet sites, but budget cuts could significantly impact the reach and efficacy of data within the R2/R4 ozone network footprint.

II. Network Performance, Changes and Updates for 2023

Network-wide, data completeness stood at 82.4%, with USFS-operated sites at 80.5%. These figures are somewhat lower than average due to difficulty of access early in the monitoring season, and a few unavoidable equipment failures later in the year.

Bad weather and deep snow cover plagued the network during springtime deployment. Initiation of data collection was delayed by a month at Douglas Pass as CDOT snowplows had buried the installation. Dark Canyon experienced a similar

delay due to impassible roads at the usual time of deployment (late April). Critical datalogger maintenance at Little Mountain was also delayed due to difficulty of access.

The Hebron Slough site was decommissioned in the spring. BLM personnel have set up a portable, multiple-pollutant monitoring station about 2km west of the site and Hebron was deemed redundant. BLM ozone data for their site are presented in this report.

Staff from the Nebraska National Forest (Rachel Palladino, Phillip Dobesh) contacted RMRS in summer 2023 and coordinated rehabilitation and reactivation of the Fort Robinson site. This site had been originally established in 2014, but lacked adequate operator support. RMRS visited the site with NENF staff in September, rehabilitated the equipment, and updated the installation to current standards. Data collection resumed on 1 September.

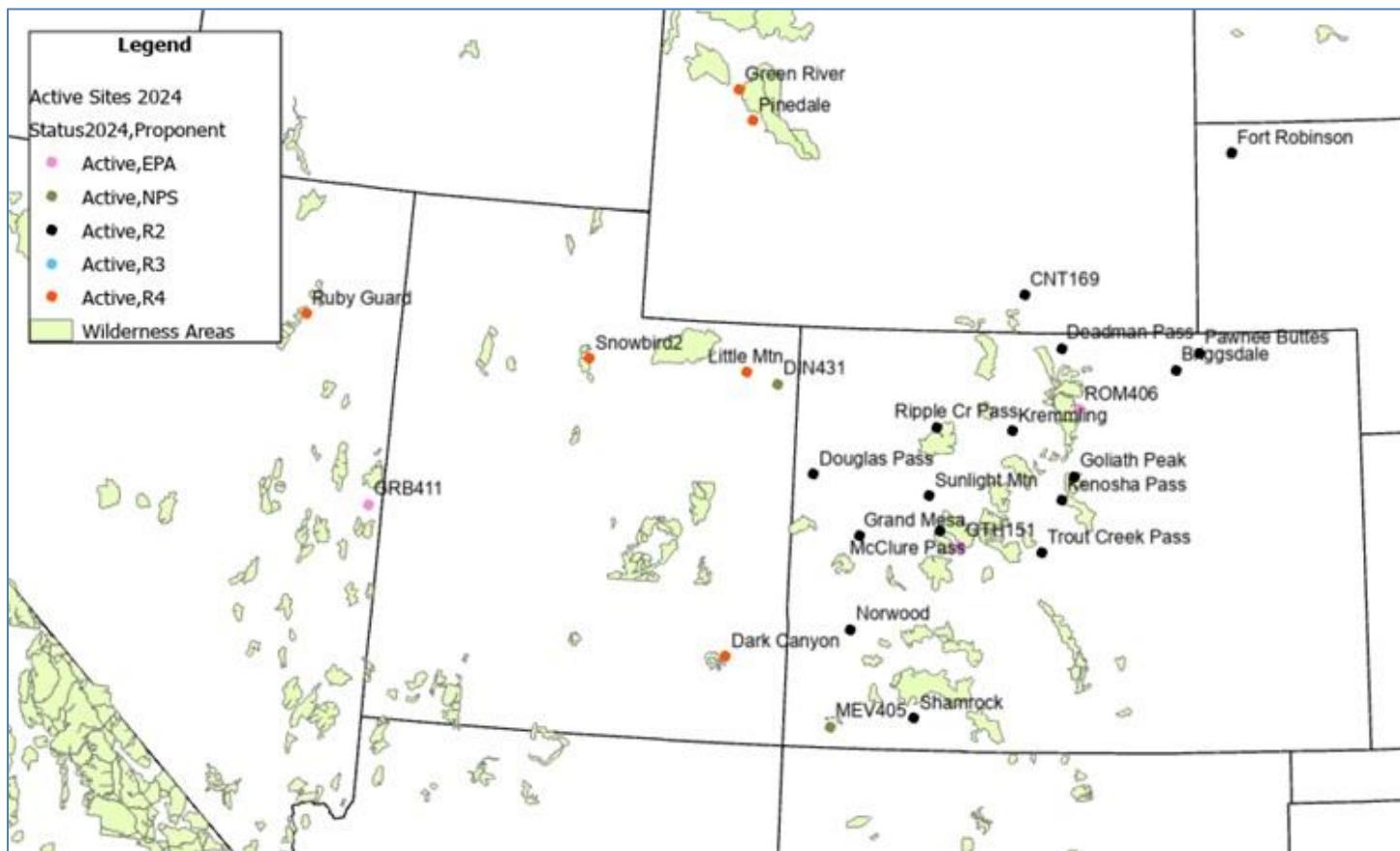


Figure 1. Ozone monitoring sites within Regions 2 and 4, 2023.

RMRS restarted the Snowbird site in early January, with the intention of beginning year-round data collection. The installation used the power supply of the co-located SNOTEL site. Unfortunately, there was insufficient solar gain to power both installations, and NRCS personnel had to shut off the ozone instrumentation after only two weeks. RMRS were unable to return to the site until early October, when an independent power supply was installed. Further modifications will take place in 2024 when the SNOTEL site is relocated about 100m from its current location.

Year-Round Sites	Forest	Begin Date	End Date	Data Completeness	Notes
Fort Robinson	NENF	1 Sep	31 Dec	86.1	Site reactivated 1 Sep
Pawnee Buttes	PNG	1 Jan	31 Dec	87.4	
Briggsdale	PNG	1 Jan	31 Dec	77.3	
Kenosha Pass	PSINF	1 Jan	31 Dec	73.2	
Sunlight Mountain	WRNF	1 Jan	31 Dec	99.1	
Little Mountain	Ashley	25 Apr	31 Oct	63.0	Datalogger malfunction
Centennial CASTNet	MBRNF	1 Jan	31 Dec	91.1	
RMNP CASTNet	RMNP	1 Jan	31 Dec	98.5	
Gothic CASTNet	GMUG	1 Jan	31 Dec	93.6	
Dinosaur NM CASTNet	NPS	1 Jan	31 Dec	97.2	
Shamrock	SNJF	1 Jan	31 Dec	81.8	No data for June
Mesa Verde CASTNet	NPS	1 Jan	31 Dec	99.3	
Snowbird	WCNF	5 Oct	31 Dec	29.2	Conflict with SNOTEL site
Canyonlands CASTNet	NPS	1 Jan	31 Dec	95.9	
GBNP CASTNet	NPS	1 Jan	31 Dec	98.8	
Seasonal Sites					
Deadman Pass	ARNF	1 May	30 Sep	25.5	
Goliath Pk	ARNF	22 May	30 Sep	94.2	
Trout Cr Pass	PSINF	28 Apr	30 Sep	98.7	
Kremmling	BLM	24 Apr	30 Sep	97.5	
McClure Pass	GMUG	27 Apr	30 Sep	97.2	
Ripple Cr Pass	WRNF	1 May	30 Sep	96.6	
Grand Mesa	GMUG	4 May	30 Sep	80.9	No Apr data due to snow cover
Norwood	SJNF	23 Mar	30 Sep	97.7	
Douglas Pass	BLM	26 Apr	30 Sep	77.9	Site inaccessible until May
Dark Canyon	MLSNF	26 May	30 Sep	70.0	Site inaccessible until late May
Ruby Guard	HTNF	10 Apr	30 Sep	93.9	No early Apr data, snow cover

Table 1. 2023 Network performance

III. Data Summary:

Ozone hazard to vegetation and human health may be assessed using a number of different metrics. The table below (Table 2) lists daytime and overnight averages, the maximum and fourth-maximum daily 8-hour averages, and the highest observed 3-month daytime W126 values. For vegetation, EPA (EPA 2015) considers 17 ppm-hr to be a general threshold for foliar damage to vegetation.

	Average O ₃ (ppb)		MDA8 (ppb)				Cumulative O ₃ (ppm-hr)	
Year-Round Sites	Daytime	Overnight	Max	Date	4 th Max	Date	Max W126	Period
Pawnee Buttes	48.0	40.8	73.9	22 May	65.9	1 Aug	12.1	Apr-Jun
Briggsdale	41.7	24.6	67.3*	11 Apr	65.6*	17 Apr	5.8*	Feb-Apr
Fort Robinson	Insufficient Data							
Kenosha Pass	51.7	48.5	84.4	23 Apr	70.1	23 Jun	18.5**	Apr-Jun
Sunlight Mountain	49.5	50.0	78.1	23 Apr	70.3	17 Apr	17.1**	Mar-May
Little Mountain	49.1	49.5	69.3	17 Aug	66.1	9 May	13.0	May-Jul
Centennial CASTNet	48.4	47.9	70.6	23 Apr	65.3	9 Apr	12.5	Apr-Jun
RMNP CASTNet	47.6	43.3	68.8	23 May	67.3	19 Jun	11.6	Apr-Jun
Gothic CASTNet	48.7	41.1	68.9	22 Apr	66.3	22 Mar	12.9	Apr-Jun
Dinosaur CASTNet	48.5	35.8	119.0	5 Feb	98.3	13 Feb	31.1**	Jan-Mar
Shamrock	45.9	39.5	66.4	1 Aug	63.4	12 May	9.0*	Mar-May
Mesa Verde CASTNet	46.4	44.2	64.8	9 Jun	62.3	10 May	10.5	May-Jul
Canyonlands CASTNet	45.1	44.0	64.5	23 Jun	63.6	27 Jun	11.4	May-Jul
GBNP CASTNet	45.9	43.5	68.6	17 Apr	65.5	7 Jul	11.2	May-Jul
Seasonal Sites								
Deadman Pass	54.7	53.5	70.9*	22 May	66.9*	8 May		
Goliath Pk	54.8	53.6	81.5	23 May	73.6	15 Aug	18.3**	Jun-Aug
Trout Cr Pass	54.2	48.2	75.9	9 May	71.2	4 May	19.6**	May-Jul
Kremmling	46.8	21.7	63.5	23 May	61.1	9 Jul	7.6	May-Jul
McClure Pass	50.4	48.1	67.0	10 May	64.3	5 May	11.7	May-Jul
Ripple Cr Pass	50.4	49.9	67.1	5 May	63.6	23 Jun	11.5	May-Jul
Grand Mesa	52.9	50.7	67.8	9 May	66.2	20 May	13.2	May-Jul
Norwood	49.6	36.3	65.5	19 Jun	63.2	6 Jul	10.7	May-Jul
Douglas Pass	54.5	54.5	71.3	23 Jun	68.7	8 Jun	14.6	May-Jul
Snowbird	Insufficient Data							
Dark Canyon	51.3	42.2	65.9	8 Jun	63.5	9 Jun	10.4	Jun-Aug
Ruby Guard	47.2	39.6	62.4	16 Apr	60.7	2 May	7.4	May-Jul

Table 2: Summary statistics for all 2023 Sites. “Average O₃” is the mean of ozone readings between 8 a.m.-8 p.m. (Daytime) and 8 p.m.-8 a.m. (Overnight) for the entire growing season (April-September). “MDA8” reports the days on which the maximum and 4th-maximum (EPA design value) 8-hour averages were recorded.

*indicates site where missing data precluded complete assessment; actual peak may not have been observed.

Deployment dates listed in Table 1.

**Value reflective of potential impact of long-term vegetation exposure; see text.

III. Discussion:

The 2023 monitoring year was a relatively benign one for surface ozone. Most of the western US experienced a modest year for wildfire, and precursor emissions region-wide were therefore fairly low. The very large and destructive Canadian wildfires, which heavily impacted air quality all summer and into autumn in eastern North America had comparatively little impact in the west. According to the Canadian Interagency Forest Fire Centre, fires had consumed nearly 13 million ha, the highest yearly total on record (CIFFC, 2023). However, the most serious air quality effects of the Canadian fires were largely confined to areas east of the Rocky Mountains in the US.

In the Front Range, modest ozone events occurred from mid-April through the end of May during the changeover from winter to summer synoptic meteorological patterns. This pattern has been typical of this area in most years when wildfire impact has been minimal. Late August also saw some elevated ozone, but lengthy, damaging events were mostly absent from the Front Range (and nearly all of the network) this year. Sites within and near the footprint of the current ozone NAAQS nonattainment area continued to produce design values (fourth-maximum MDA8) over the current 70 ppb NAAQS.

RMRS now has sufficient data to begin making some longer-term assessments of conditions at its sites. Of particular note is Kenosha Pass, about 80 km southwest of Denver. This site, in Park County, is outside of the Front Range nonattainment area, but has exhibited surprisingly high ozone levels since monitoring began in 2007.

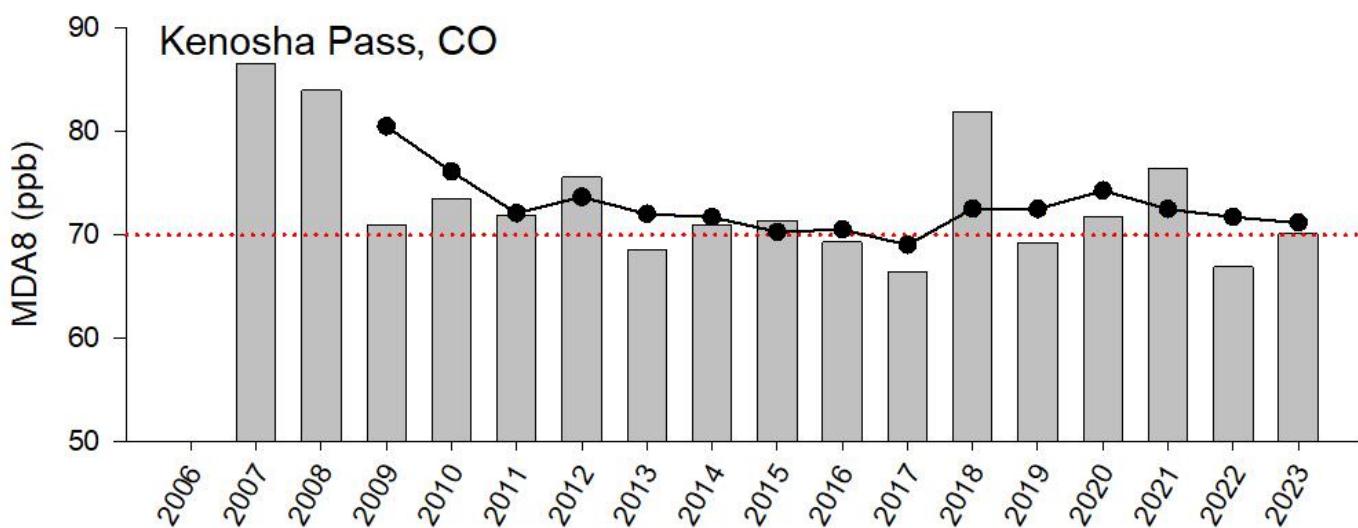


Figure 2. Fourth-maximum design values (MDA8) at Kenosha Pass, 2007-present. The vertical bars are values for individual years, and the black line indicates the three-year average regulatory values.

The three-year average regulatory figures at Kenosha Pass have been over the 70 ppb NAAQS in every averaging period except 2015-2017. Were the data from this site regulatory, Park County would very likely be included in the nonattainment area. The very large (and heavily visited) aspen forest in this area should be surveyed for potential foliar damage.

Another site with notable potential for vegetation hazard is Snowbird, immediately downwind of the greater Salt Lake City metro area. Design values here have also consistently exceeded the NAAQS.

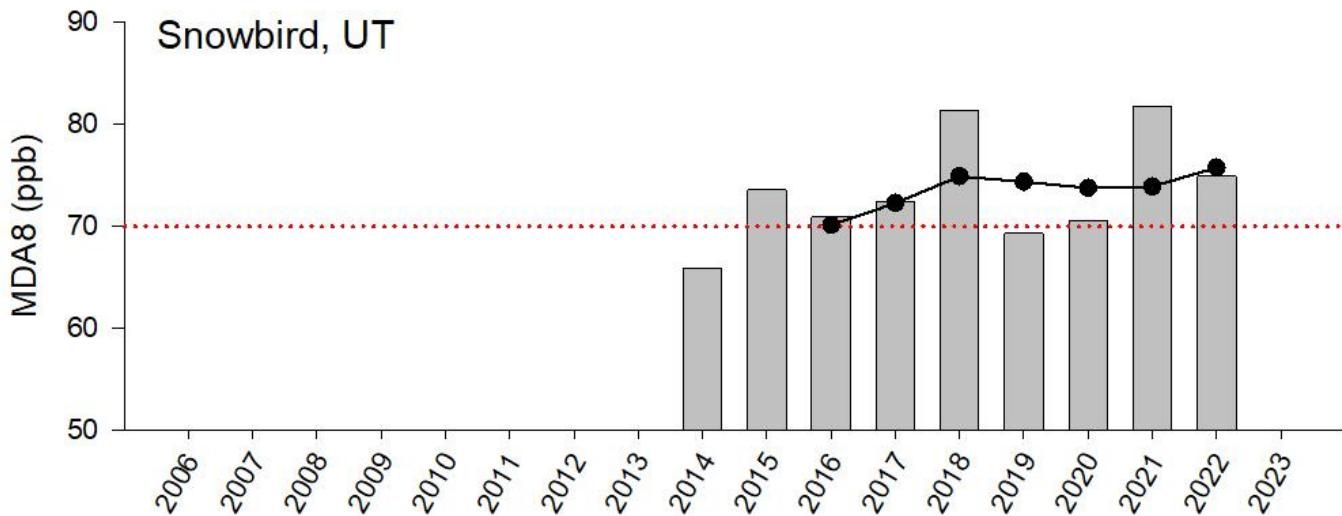


Figure 3. Fourth-maximum design values (MDA8) at Snowbird, 2014-present. The vertical bars are values for individual years, and the black line indicates the three-year average regulatory values.

Like Kenosha Pass, this area receives heavy visitor traffic and is home to ozone-sensitive plant species. This site is within the Wasatch Front nonattainment area. Aspen can experience reduced growth at fairly low exposure levels (5.8% at 10 ppm-hr, Lee et al. 2022). W126 calculated for these two sites is consistently well over 10 ppm-hr. A more comprehensive long-term analysis of the network's ozone data is in process, publication TBA.

No events of great significance occurred at Colorado west slope sites in 2023, with the exception of two moderate-length events at Sunlight Mountain, near Glenwood Springs.

Farther west, within the Region 4 footprint, conditions were also largely benign, with one very notable exception. The Uintah Basin, known to have experienced some extreme surface ozone events in the past, had been largely quiet for the past several years. However, extended periods of very high surface ozone occurred in the January-March timeframe of 2023. The CASTNet site at Dinosaur National Monument recorded a three-month W126 value of 31 ppm-hr; had this occurred during the growing season, it would have been cause for serious alarm in terms of foliar damage and tree growth potential. The extreme values seen at Dinosaur were also observed at several state monitoring sites in the Uintah Basin.

Year-Round Sites	2021	2022	2023	2021-2023 Avg
Pawnee Buttes	79.5	68.9	65.9	71.4
Briggsdale	78.2	71.9	65.6	71.9
Kenosha Pass	76.5	66.7	70.1	71.2
Sunlight Mtn	68.7	63.6	70.3	67.5
Little Mtn	76.7	62.0	66.1	68.3
Hebron Slough	71.6	62.8		
Centennial CASTNet	72.1	66.6	65.3	68.0
RMNP CASTNet	77.8	69.8	67.3	71.6
Gothic CASTNet	65.0	65.3	66.3	65.5
Dinosaur CASTNet	68.1	63.4	98.3	76.6

Shamrock	66.4	63.4	63.4	64.4
Mesa Verde CASTNet	67.8	64.1	62.3	64.7
Canyonlands CASTNet	69.1	63.5	63.6	65.4
GBNP CASTNet	68.6	61.6	65.5	65.2
Seasonal Sites				
Deadman Pass	83.3	70.8		
Goliath Pk	84.1	73.3	73.6	77.0
Trout Cr Pass	72.8	69.1	71.2	71.0
Kremmling	67.7	63.7	61.1	64.2
McClure Pass	68.4	67.6	64.3	66.8
Ripple Cr Pass	72.0	64.0	63.6	66.5
Grand Mesa			66.2	
Norwood	67.4	67.0	63.2	65.9
Douglas Pass	71.6	66.8	68.7	69.0
Snowbird	81.8	74.9		
Dark Canyon		62.6	63.5	
Ruby Guard	75.4	61.5	60.7	65.9

Table 3. Fourth-maximum daily values (MDA8) and three-year averages. Red indicates exceedance of NAAQS.

IV. Funding.

Source	Jobcode	Allocated, FY22	Expended	Balance, end FY23
Region 2	NFVW16	5000	4643	357
ARNF	NFVW10	5000	5000	0
Ashley NF	NA	0	0	0
Total		10000	9643	357

Table 5. Non-RMRS funding sources, expenditures and remaining balance, ozone data collection and analysis, FY23

V. Acknowledgments:

RMRS are grateful for the assistance of site operators Helen Kempenich and Andrea Holland (retiree volunteers), Chris Plunkett and Kevin Faucher (Ashley NF), Rachel Palladino and Phillip Dobesh (Nebraska NF), and David Eiriksson (NRCS-Salt Lake City). Their efforts result in increased efficiency of this project and enable considerable cost savings. RMRS also thanks Clyde Sharp and Bret Harkwell, Air Quality Division, CDPHE, for their efforts to conduct audits at many of the RMRS sites.

VI. Literature Cited:

CIFFC 2023. Canadian Interagency Forest Fire Centre situation report, 1 Sep 23. <https://ciffc.net/situation/2023-08-31>. Accessed 19 Apr 24.

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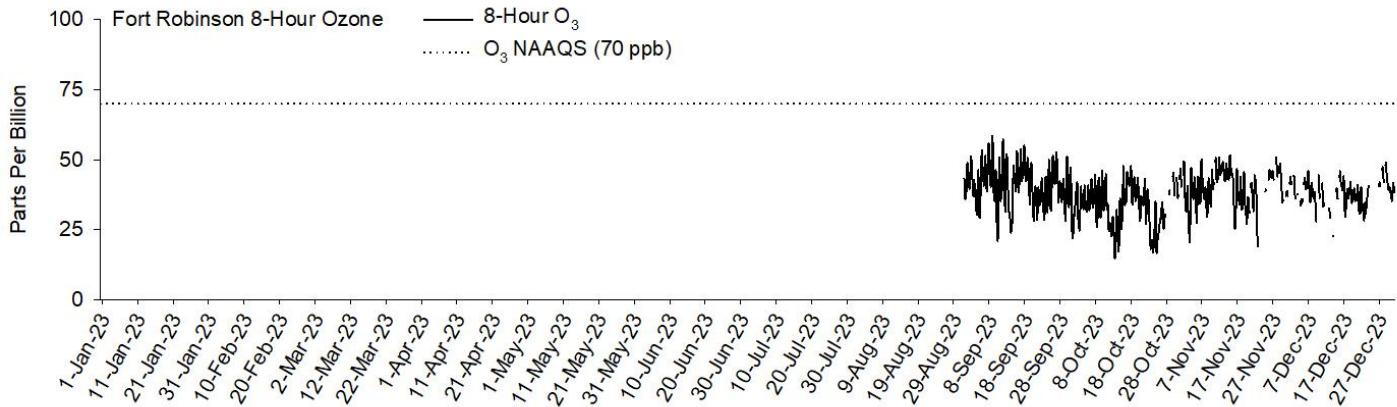
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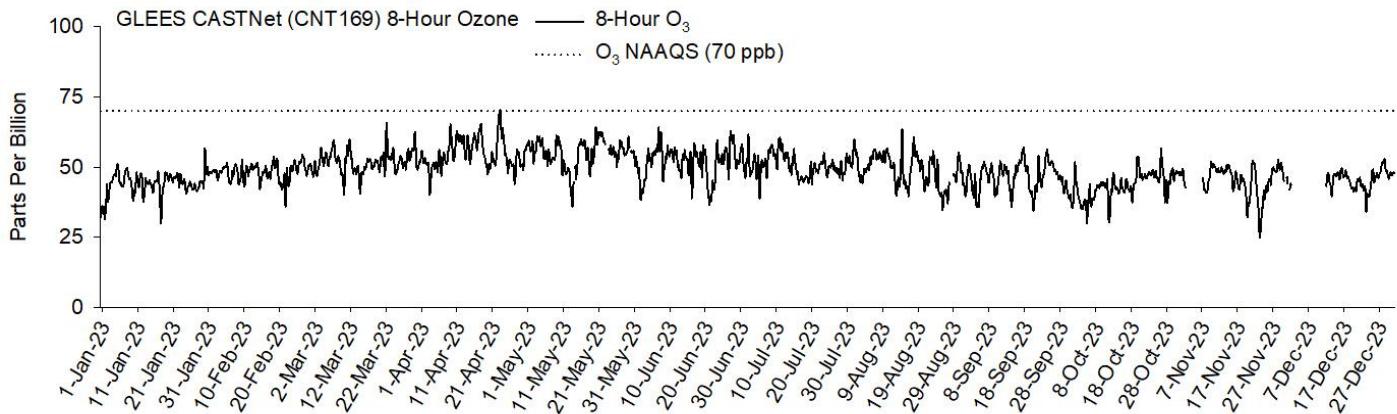
Appendix. Individual Site Data and Discussion.

Region 2 Sites.

1. Fort Robinson. This site, dormant since early 2013, was rehabilitated on September 1st, 2023, with NENF operators Rachel Palladino and Phil Dobesh assisting. Valid figures for maxima, W126, etc. are not available, but should be for 2024.

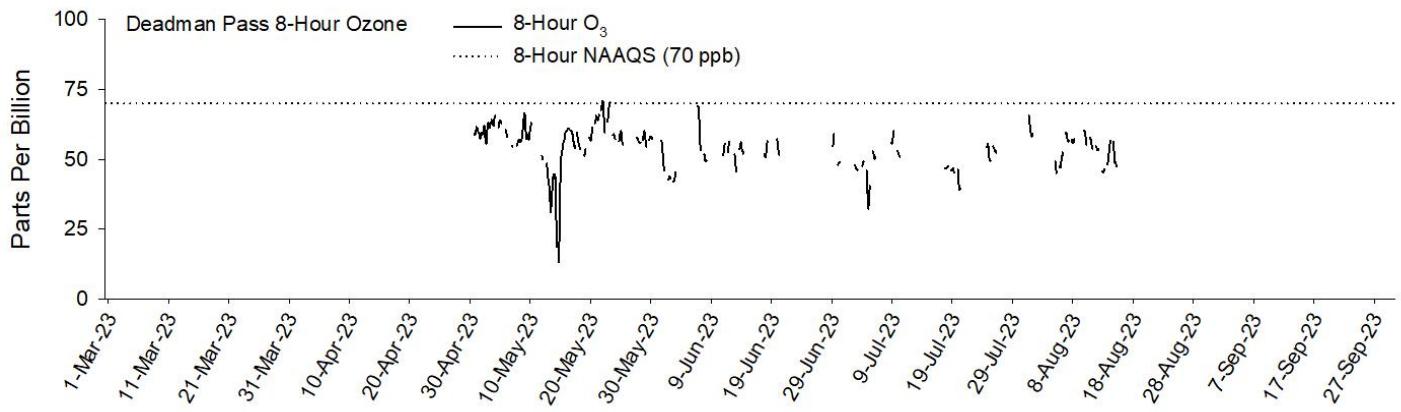


2. Centennial CASTNet. Peak ozone continued a downward trend since 2021, with April seeing the highest readings of the year (design value of 65.3 ppb). This event was the only occurrence of significantly elevated ozone in 2023, and it produced the only readings over 70 ppb.



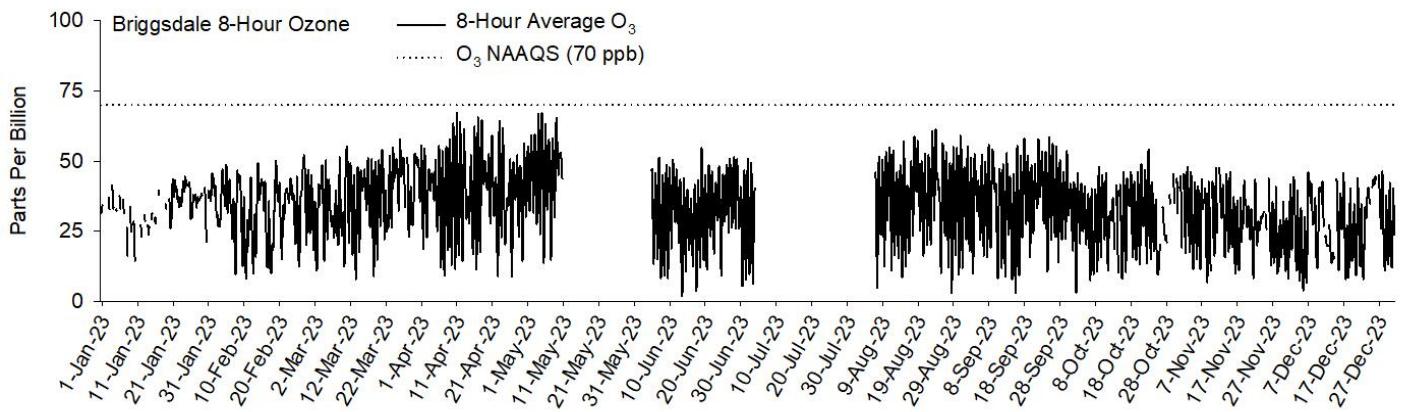
At 12.5 ppm-hr, the site's peak W126 figure indicates no vegetation hazard at present. CNT169 is CASTNet's highest, windiest, and most expensive station; discussions with the site operator (RMRS) about continuing funding for the site are ongoing at the time of publication. In continuous operation since 1989, the site has provided an important record of ozone in a remote, high elevation setting.

3. Deadman Pass. Power supply issues plagued this site in 2023, with the problem eventually diagnosed as an internally shorted storage battery. The battery was replaced at the end of the season, but, regrettably, only very limited data were collected this year.



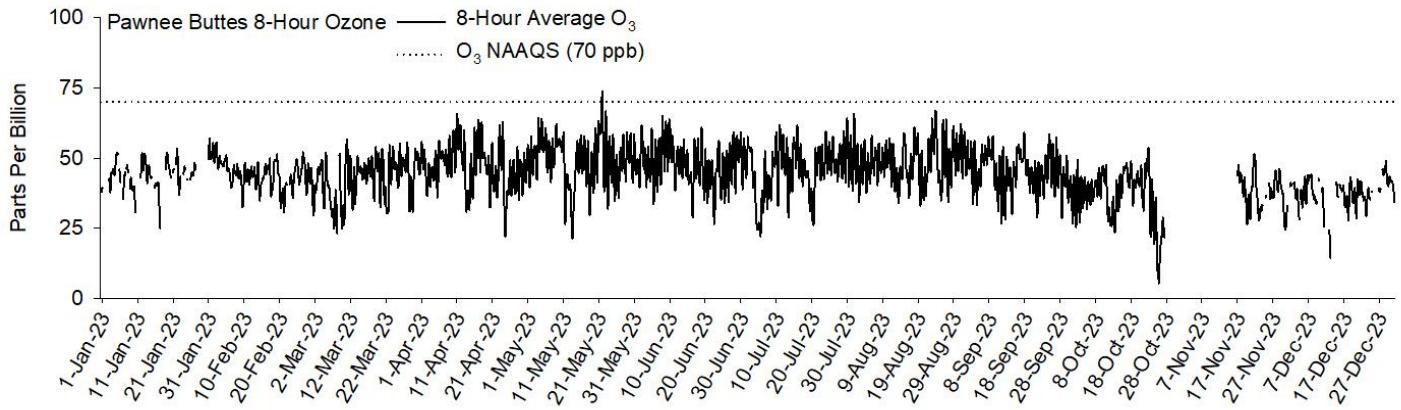
Data were insufficient to make any conclusions about conditions at the site. However, even if the very low design value observed at the site in 2023 (66.9 ppb) were valid, Deadman would remain well over the NAAQS.

4. Briggsdale. Equipment failures also plagued Briggsdale in 2023, with analyzer air pump malfunctions resulting in no data being collected during most of May and July. The year's highest ozone numbers likely occurred during May (see Pawnee Buttes below), so no figures for design value or peak W126 are available.



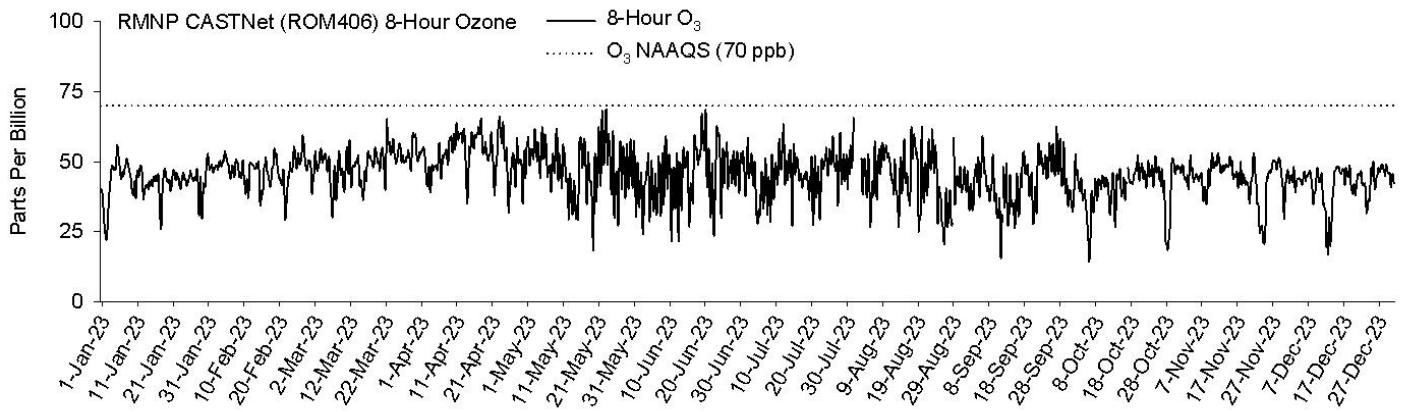
For the data that are available, the usual trends were in place at the site, with significant overnight titration of ozone and daytime peak values typically in the 50s to low 60s ppb.

5. Pawnee Buttes. A brief period of elevated ozone occurred in late May, with the year's highest 8-hour average seen on May 22nd (73.9 ppb) and the design value (65.9) recorded later in the year on August 1st. Despite having progressively lower design values in 2022 and 2023, the three-year average remains over the NAAQS at 71.4 ppb.



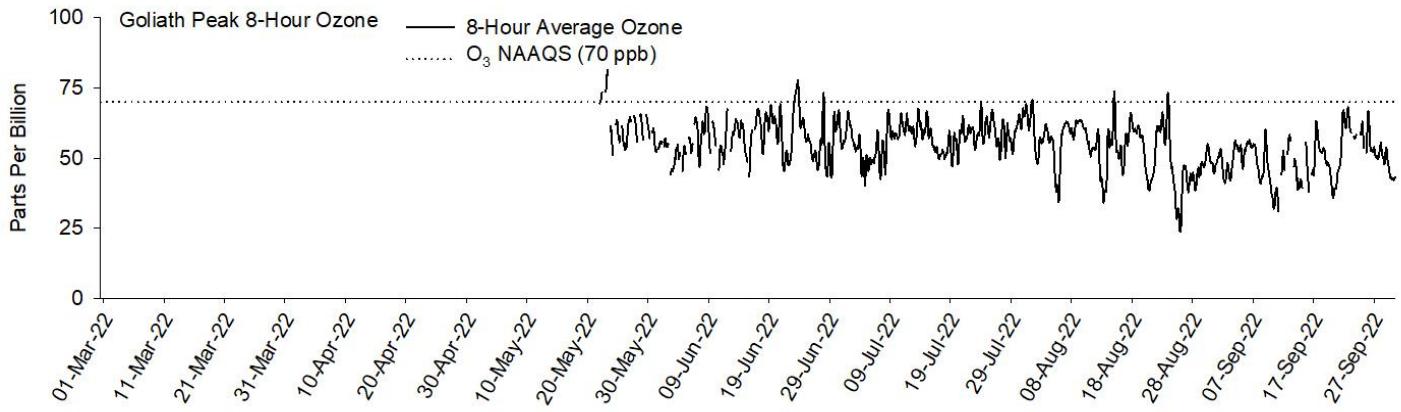
No events occurred in 2023 that are judged to be potentially harmful to native vegetation at the site. Highest three-month W126 was 12.1 ppm-hr (April-June) which is under the accepted threshold for vegetation hazard.

6. RMNP CASTNet. As at Pawnee Buttes, ambient ozone levels have been decreasing since 2021. Although the site's three-year design value average remains over the NAAQS at 71.6 ppb, a benign 2024 value may place the site's average under 70 ppb. For perspective, the RMNP CASTNet site's three-year averages have exceeded the NAAQS in 10 of the previous 16 years. No 8-hour averages exceeded 70 ppb in 2023, although the late-May and mid-June events observed elsewhere in the Front Range were evident at RMNP.



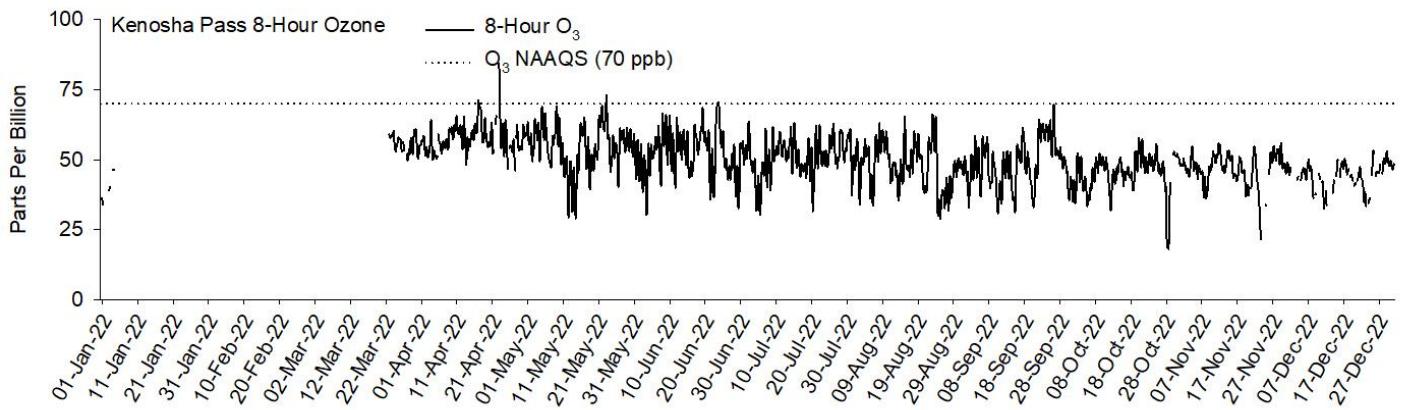
Vegetation hazard was minimal in 2023, with the highest three-month W126 observed in the April-June time frame (11.6 ppm-hr). Sensitive species such as quaking aspen and cutleaf coneflower, common in RMNP, were not impacted this year.

7. Goliath Peak. Due south of RMNP at 3518m near Mt. Blue Sky (formerly Mt. Evans), Goliath Peak remains the most impacted Front Range site. As in most year, the site was not accessible until late May. However, it's likely that the year's highest O3 readings were observed on May 23rd, one day after the site was activated for the season. Fifteen-minute averages peaked over 100 ppb, and the 8-hour average observed on that date (81.5 ppb) was the year's highest. Fourth-maximum 8-hour average (73.6 ppb) was seen during a short-duration event on August 15th. Several other short-duration events approached or exceeded 70 ppb in late June, late July and late August.



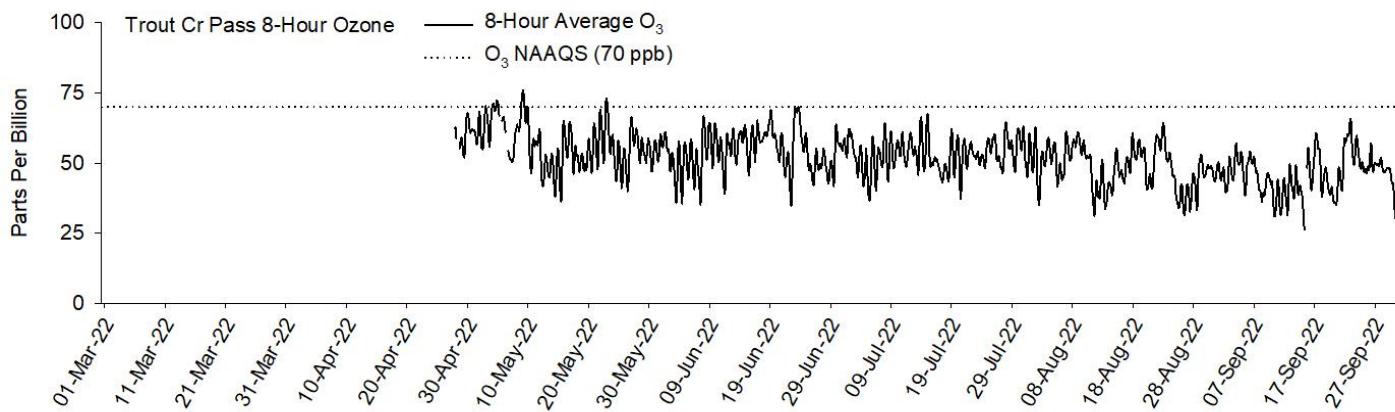
The three-month W126 figure of 18.3 ppm-hr is above vegetation hazard threshold. This site has experienced concerning ozone levels every year for which reliable data are available; aspen and other sensitive species should be observed for foliar damage.

8. Kenosha Pass. Ozone peaked at Kenosha on April 23rd, with 15-minute averages just under 90 ppb. This date also saw the year's highest 8-hour average (84.4 ppb). A longer, lower-amplitude event on June 23rd produced the fourth-maximum 8-hour figure of 70.1 ppb. Kenosha remains well over the NAAQS with the 2021-2023 design value average at 71.2 ppb. Since 2006, the 2015-2017 design value average (69.0 ppb) is the only three-year period under the NAAQS.



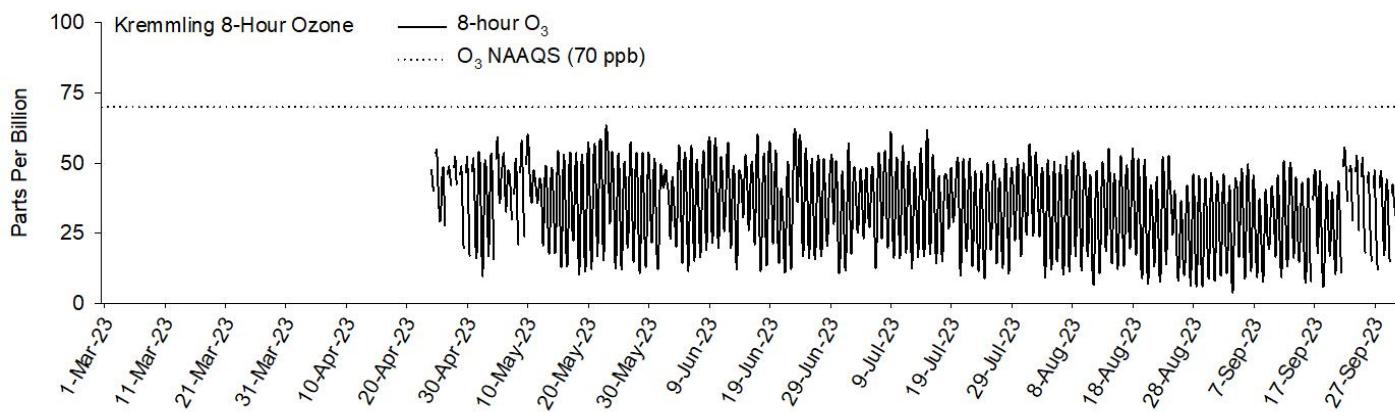
The area surrounding the Kenosha Pass site is home to a very large (and heavily visited) aspen grove. Trees in this area should be checked for foliar damage; the three-month W126 (18.5 ppb-hr in 2023) is over the hazard threshold.

9. *Trout Creek Pass*. This site completes the southern Front Range trifecta of places with potential ozone impact. Unlike many other sites in the intermountain west, ozone levels have been consistently rising at Trout Creek. This year's maximum and fourth maximum 8-hour averages (75.9, May 9th; 71.2, May 4th) resulted from longer-duration events, during both of which ozone of more than 60 ppb persisted for about 60 hours.



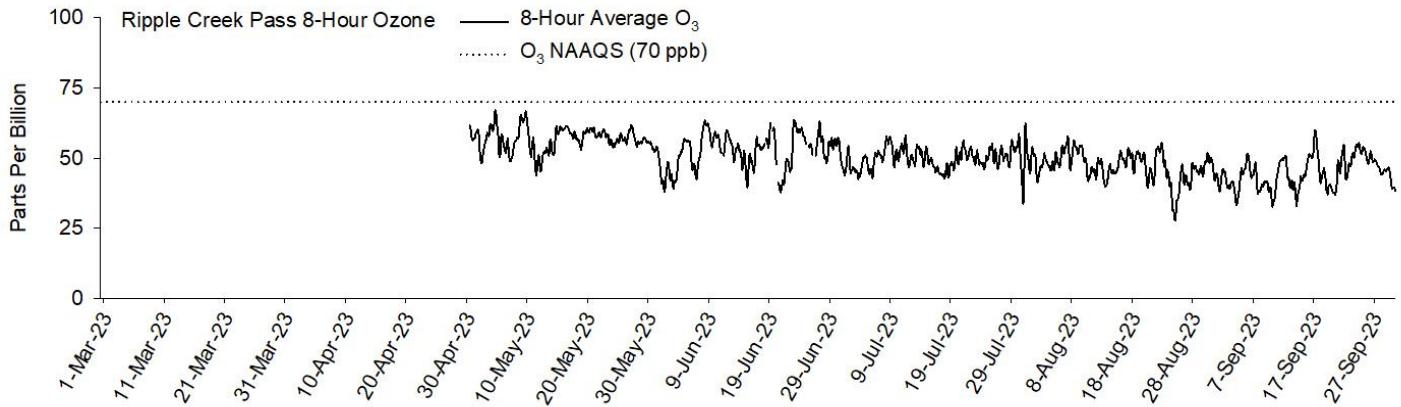
Trout Creek Pass occupies an unusual position both in terms of atmospheric properties (the pass connects Arkansas Valley and Front Range airsheds) and botanically (nearly all Colorado-native conifers can be found within 1 km of the site). Ponderosa pine and aspen are common in the vicinity of the site and should be observed for foliar damage; peak 3-month W126 (19.6 ppm-hr, May-July) was the highest observed on the network in 2023.

10. *Kremmling*. Traveling the 150 km northwest from Trout Creek to Kremmling is a trip from worst to first: Kremmling remains among the least-impacted sites on the network, and the 61.1 ppb design value was lowest of all in 2023. Kremmling's (relatively) low elevation and isolation from large precursor sources keeps surface ozone levels low.



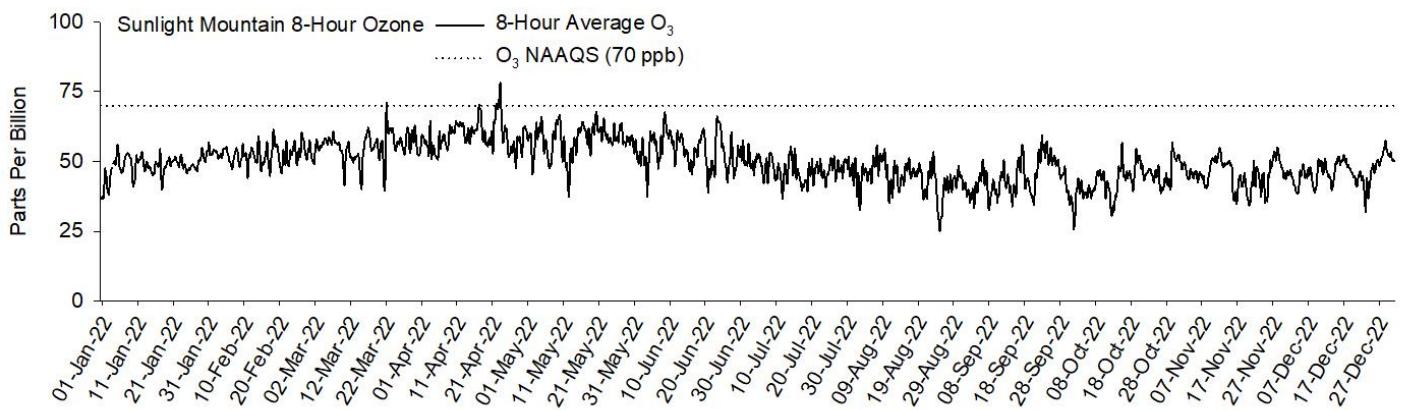
Kremmling is one of the few sites to have not experienced levels hazardous to vegetation since the beginning of monitoring at this site in 2015. This year's peak W126 figure of 7.6 ppm-hr is the lowest among all sites with sufficient data.

11. Ripple Creek Pass. At the edge of the Flat Tops Wilderness, this site is also remote from significant precursor sources. No events produced 8-hour averages exceeding 70 ppb in 2023, and only three 15-minute readings (all on May 5th) topped 70 ppb. Max (67.1 ppb, May 5th) and 4th-max (63.6 ppb, June 23rd) 8-hour averages resulted from non-hazardous, short-duration events. Ripple Creek Pass remains well within the ozone NAAQS.



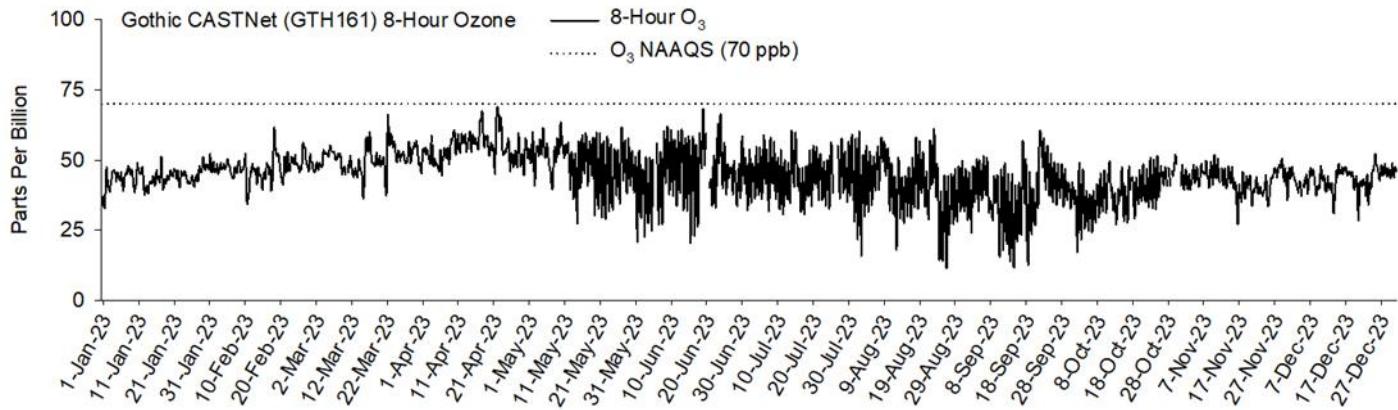
At 11.5 ppm-hr (May-July), the peak W126 figure indicates no significant vegetation impact is occurring at the site.

12. Sunlight. This site monitors air quality upstream of the Roaring Fork Valley and extensive Class I wilderness areas in the Elk Range. The same event that produced very high readings at Kenosha Pass also caused the year's highest observations at Sunlight. The design value, 70.1 ppb, was observed in April 17th, just prior to the peak 8-hour figure of 78.1 ppb on April 23rd. Ozone averaged 62.8 ppb for the period of April 15th through April 24th, an unusually long-duration event. However, Sunlight remains within the NAAQS and has not had a 3-year average over the NAAQS since 2013-2015.



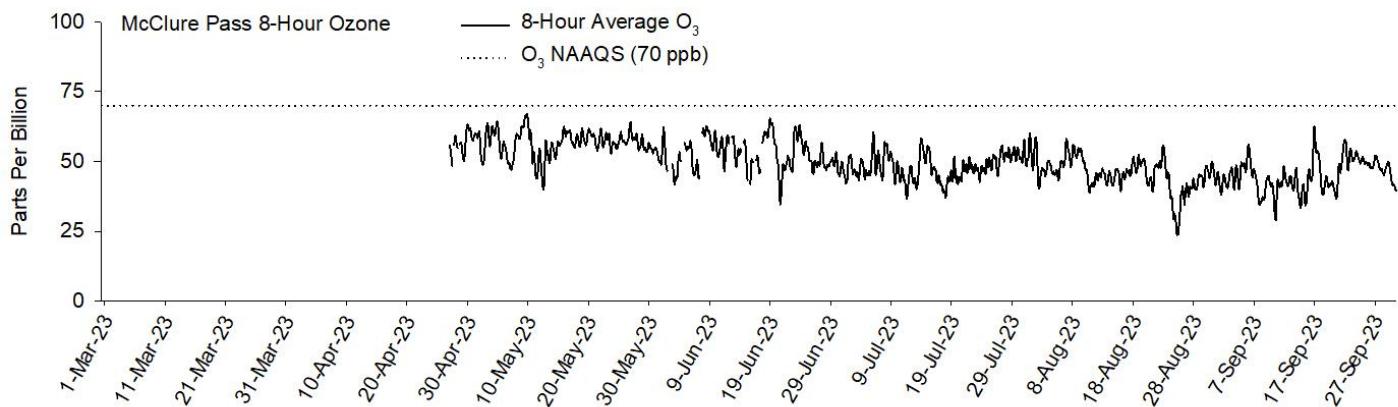
At 17.1 ppm-hr, Sunlight experienced marginally hazardous levels of ozone in 2023. The immediate south slope of the mountain that is home for the monitoring site, and the surrounding area, has extensive aspen forest cover. These trees are especially sensitive to ozone necrosis and should be checked for damage.

13. *Gothic CASTNet*. On the other side of the Elk Range from Sunlight, Gothic saw very similar patterns of surface ozone, but generally at a lower amplitude (daytime average of 48.7 ppb; Sunlight=49.5). Gothic's peak 8-hour readings and design values were within acceptable limits (68.9 ppb, April 22nd; 66.3 March 22nd) and somewhat lower than those seen at Sunlight. Gothic's three-year design value average of 66.5 ppb remains well below NAAQS and continues a long-term trend of low ambient ozone: this site has not exceeded the NAAQS since the beginning of monitoring on the RMRS network.



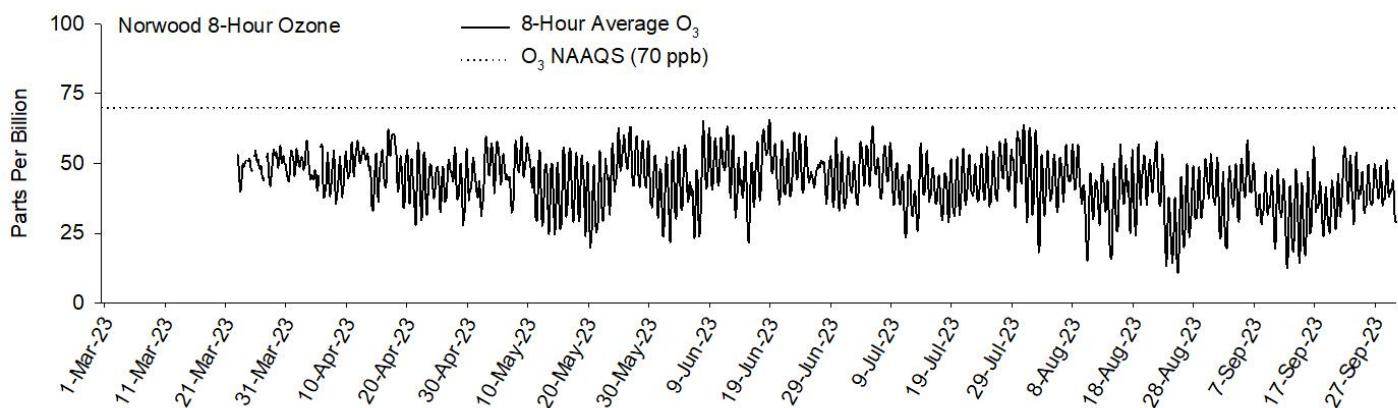
The peak 3-month W126 of 12.9 ppm-hr indicates no current vegetation hazard.

14. *McClure Pass*. The third of three sites in the vicinity of the Elk Range, McClure sits on the airshed boundary between the Gunnison and Roaring Fork basins. Patterns were largely similar to those at Sunlight and Gothic, with no 8-hour averages over 70 ppb. Early May saw the year's highest ozone, with a few hours of 70+ ppb. McClure Pass has not exceeded the NAAQS since it was established in 2010.



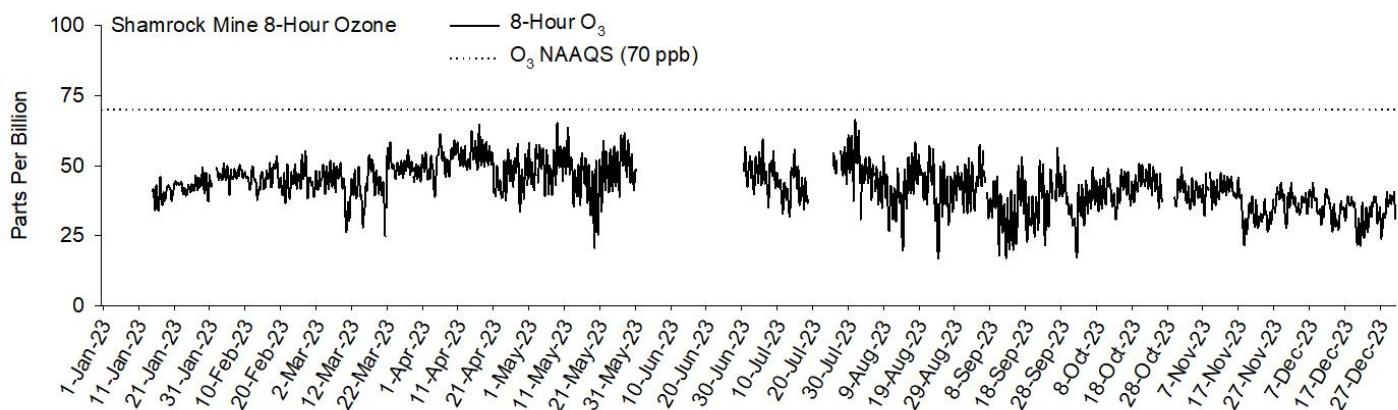
The peak 3-month W126 for 2023 was 11.7 pm-hr (May-July) with no vegetation hazard indicated.

15. *Norwood*. The benign characteristics of surface ozone at Norwood differ from other West Slope sites only in the timing of peak events. Later than most, Norwood's 8-hour average peaked on June 19th (65.5 ppb), and the design value (63.2 ppb) on July 6th. Norwood was unique, however, in that no 15-minute average readings exceeded 70 ppb in 2023. The long-term trend at Norwood is slightly downward, with no 3-year design value averages over 67.4 ppb.



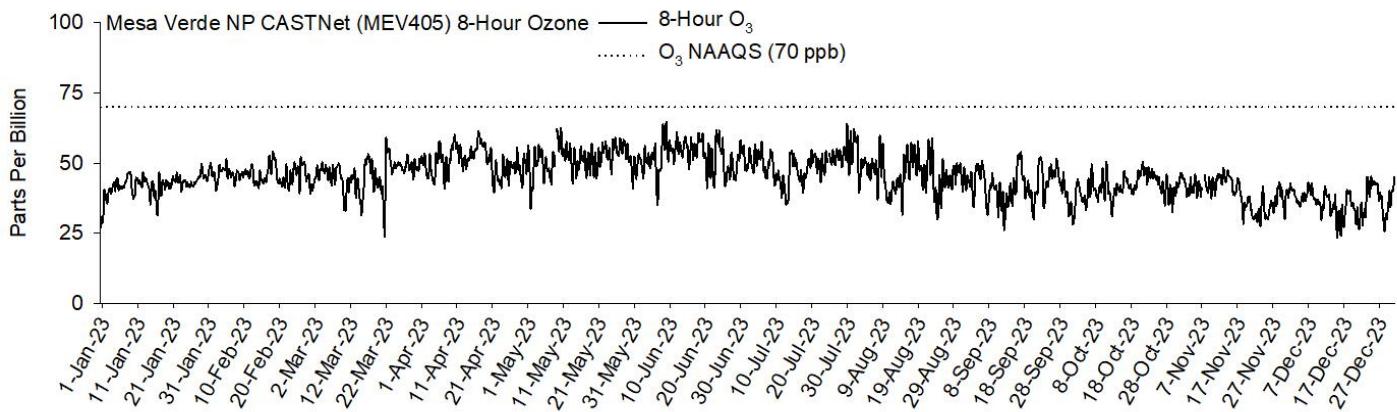
No vegetation hazard exists at Norwood (peak W126 of 10.7 ppm-hr, May-July).

16. *Shamrock*. Spring and summer equipment problems plagued this contractor-run site on the southern periphery of the Weeminuche Wilderness in southwestern Colorado. Although critical late-spring and early summer data are missing, patterns are otherwise similar to those at Norwood; peak values in the existing data indicate that no ozone events of great concern occurred here in 2023.



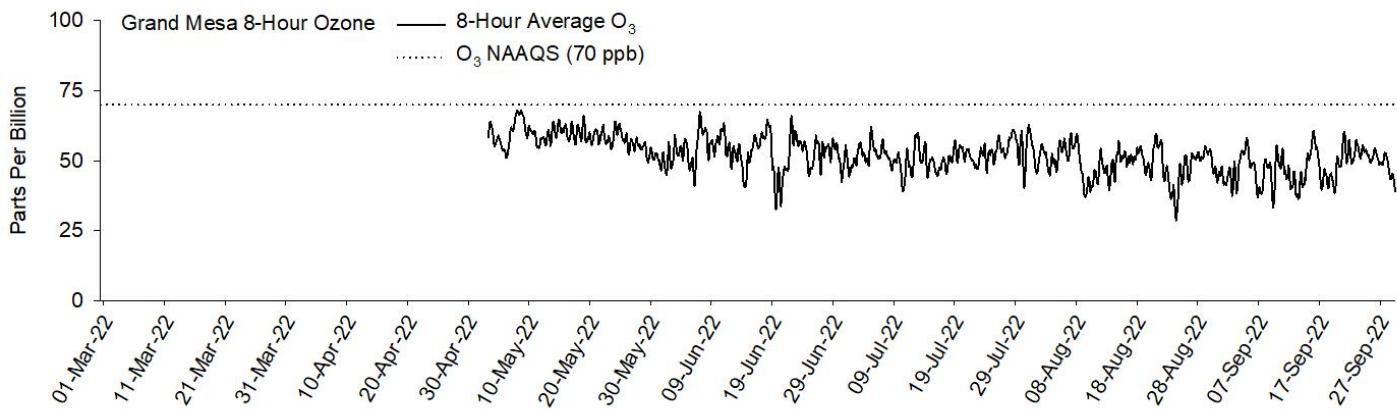
The three-month period of May-July saw the highest, though benign, ozone exposure at surrounding sites, a period which cannot be assessed at Shamrock. However, the data collected do not suggest that conditions at Shamrock differed greatly.

17. Mesa Verde CASTNet. An event on March 22nd, likely passage of a strong cold front, produced an emphatic spike in surface ozone (from 22 ppb to 65 ppb in two hours). This event was also observed at other West Slope stations, although with less dramatic changes. No long-duration ozone events occurred at this beautiful national park, and the design value (62.3 ppb, May 10th) remains well below NAAQS.



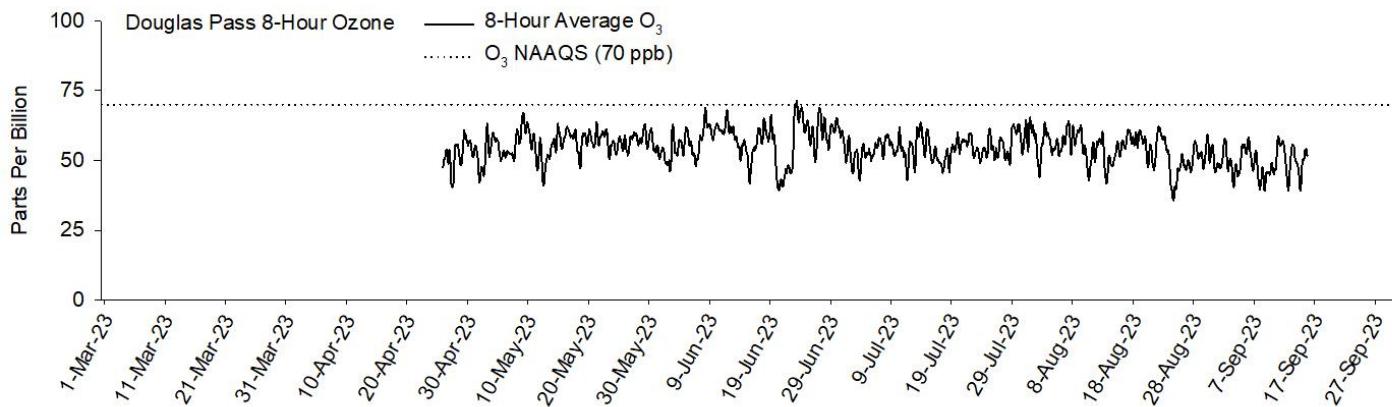
At 10.5 ppm-hr (May-July), W126 indicates no current vegetation hazard.

18. Grand Mesa. After several years of equipment failures and other logistical challenges, Grand Mesa returned a full season of surface ozone data in 2023. High levels were seen in late spring, with a 36-hour period (May 8th-10th) averaging 61.0 ppb. No other long-duration events were recorded, however, and the maximum and 4th-maximum 8-hour averages (67.8, May 9th; 66.2 May 20th, respectively) are similar to numbers from previous years.



Vegetation hazard is slightly elevated (W126 of 13.2 ppm-hr, May-July) at this high-elevation site compared to adjacent sites, but is not currently cause for alarm.

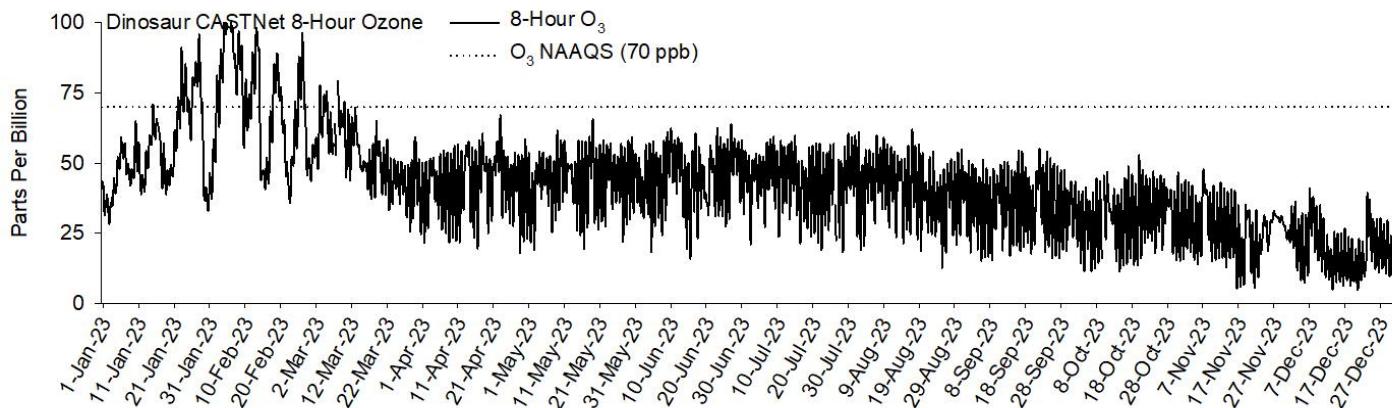
19. *Douglas Pass*. Data collection was delayed by one month at Douglas Pass due to very deep snow accumulation (i.e., CDOT used the site to dispose of accumulated snowplow debris). Moderate damage to the site was repaired in late April and seasonal data collection was initiated. This year's design value (68.7 ppb, June 8th) kept the three-year average just below NAAQS (2021-2023, 69.0 ppb). This is the highest figure for the site on record. Higher numbers (1st-maximum of 71.3 ppb) were seen in late June. This event was relatively short-lived (average of 66.6 ppb for 18 hours) and was the only event of concern in 2023.



Exposure was higher than most years (W126 14.6 ppm-hr, May-July) and is the highest figure observed since 2018. Although not yet concerning, continued W126 numbers near the hazard threshold of 17 ppm-hr may warrant observation of vegetation for foliar damage.

Region 4 Sites.

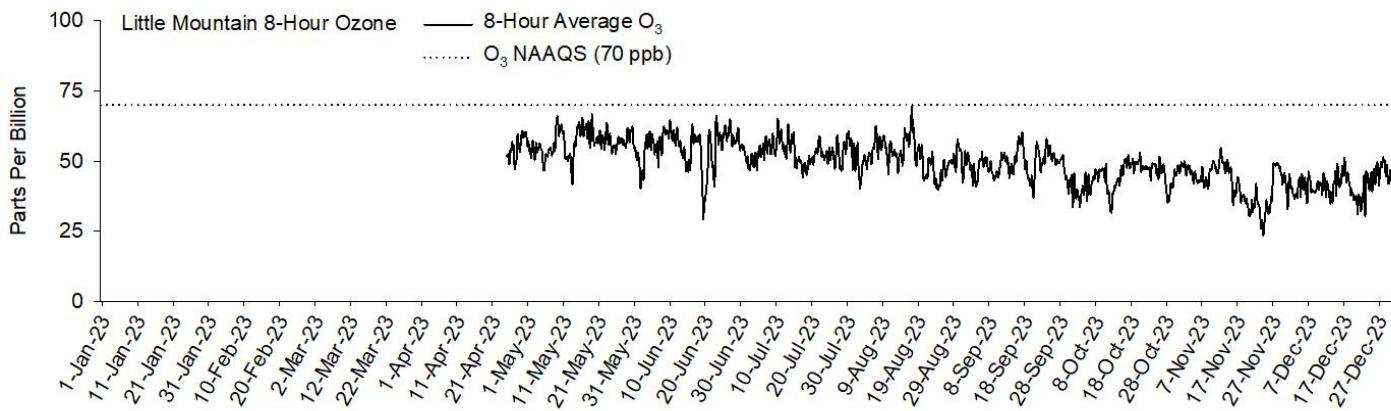
20. *Dinosaur National Monument CASTNet*. Utah's Uintah Basin experienced extensive, emphatic surface ozone events for several years in the 2010s due to a combination of oil and gas field emissions, temperature inversions and other meteorological factors. By 2020, this issue seemed decreased in severity, and the area enjoyed a few years of fairly good air quality. However, in 2023, the Dinosaur NM CASTNet, and all other Utah DEQ monitoring sites in Uintah County, experienced a prolonged, emphatic period of elevated ozone where surface mixing ratios regularly exceeded 100 ppb. The design value, 98.3 ppb (February 13th), is the highest ever in RMRS reports, and the first-maximum, 119.0 (February 5th) also shares this dubious distinction.



Dinosaur's three-year average (76.4 ppb) is, unsurprisingly, well over the NAAQS and Uintah County will remain within the designated nonattainment area for some time. The peak 3-month W126 (31.3 ppm-hr, January-March), while alarming, occurred well before the growing season began. By spring, surface ozone had subsided to the benign levels

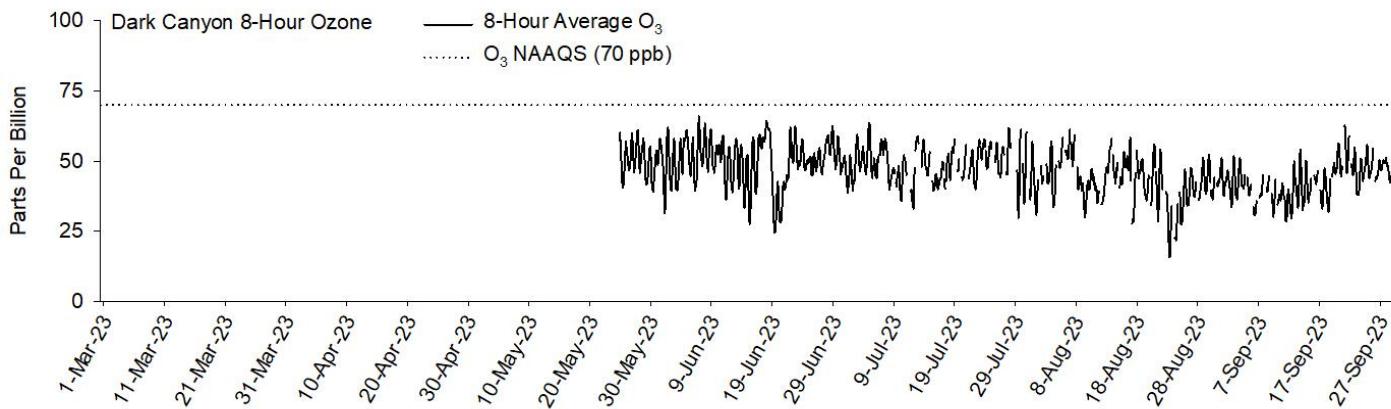
that have been observed here since 2020. The highest growing season exposure figure, 12.8 ppm-hr (March-May) is below hazard threshold.

21. Little Mountain. Corroborating the extraordinary data from Dinosaur (above) would have been interesting...but the Little Mountain installation suffered an unexplained datalogger failure the previous October, and no site visit to correct the problem was possible until a ski-mounted expedition was mounted by RMRS and Ashley NF site operator Chris Plunkett in April. The growing-season data collected is nevertheless useful. No events exceeded 70 ppb (first maximum 8-hour of 69.3 ppb, August 17th) and the design value of 66.1 ppb was observed on May 9th. Little Mountain has remained under the NAAQS three-year average since 2021.



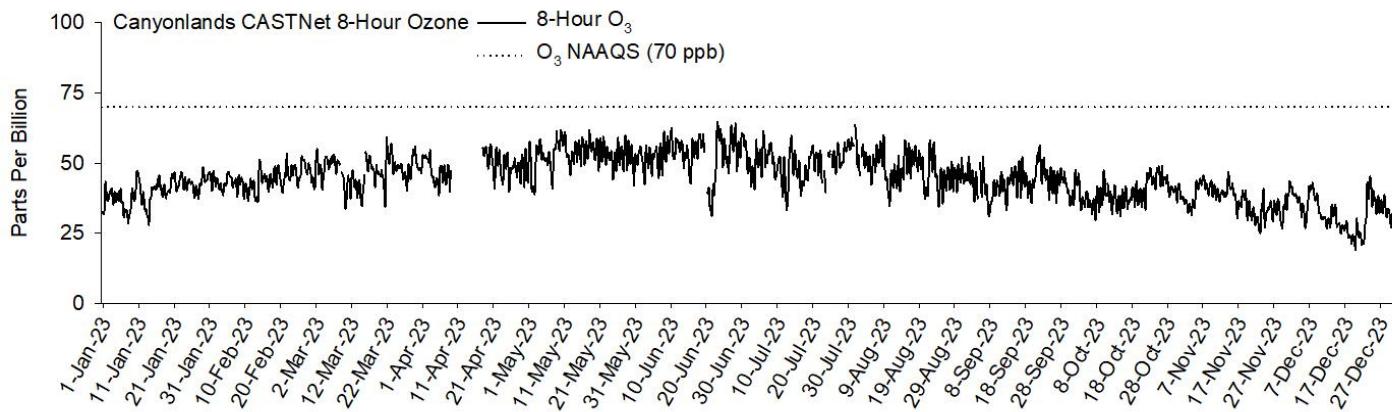
Historically, the very high surface ozone at low elevation in Uintah County has not been observed at Little Mountain, which is 1000m higher than the valley floor. Inversions which help create the valley floor conditions usually prevent ozone from mixing to higher elevations to any great degree. Without early spring data, it is not possible to know all aspects of potential ozone impact at Little Mountain. However, the period of data collection corresponds roughly with the growing season at the site's elevation, and the three-month W126 figure is 13.0 ppm-hr (May-July).

22. Dark Canyon. Early season access was also prevented by snow accumulation at this station adjacent to the Dark Canyon Wilderness. The station was up and running by late May, and recorded a full season of data otherwise. A steep drop in surface ozone (mid-June, 30 ppb change over four hours), although seen at most sites in the western half of the network, was most emphatic here. Surface ozone remained well below 70 ppb for the remainder of the monitoring season, with the design value of 63.5 ppb occurring on June 9th.



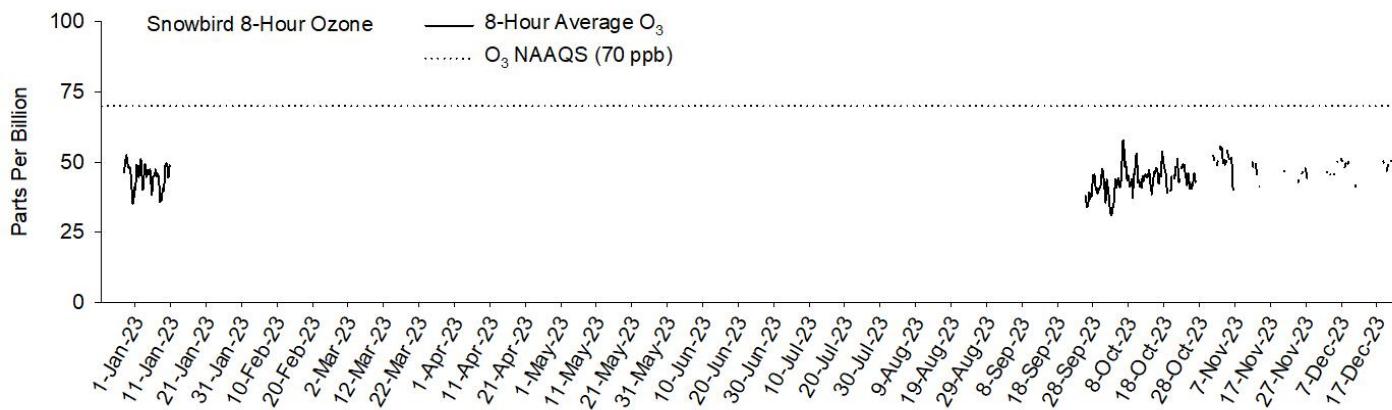
Historically, Dark Canyon has not experienced hazardous surface ozone, and 2023 was no exception. Peak W126 was 10.4 ppm-hr (May-July).

23. *Canyonlands NP CASTNet*. Most sites on the western half of the network, Canyonlands CASTNet included, experienced a low-key 2023 for ozone. The late-spring drop very evident 120 km to the south at Dark Canyon was also visible in the Canyonlands data. Otherwise, no notable events occurred. First/fourth maxima for 8-hour averages (64.5 ppb, June 23d; 63.6 ppb June 27th) highlighted a brief period of slightly elevated ozone.



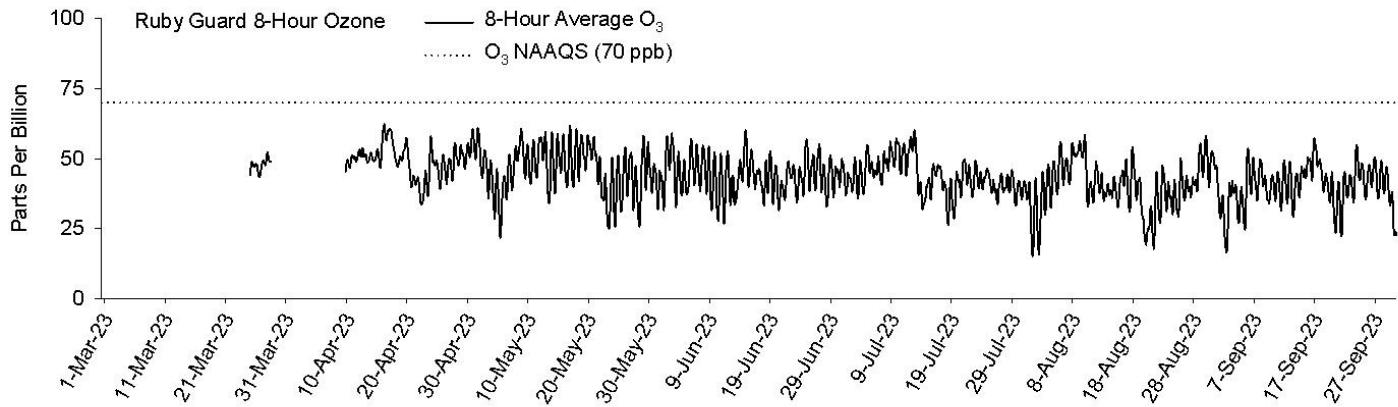
As in most of the period of record at this site, no significant vegetation hazard is evident.

24. *Snowbird*. Plans to begin year-round data collection at Snowbird were unsuccessful. After instruments were reinstalled in early January, the solar and battery capacity at the site (an NRCS SNOTEL site) were insufficient to run both the SNOTEL and ozone monitoring equipment. NRCS personnel operating the site were forced to shut off the ozone installation in order to permit SNOTEL data collection. RMRS were unable to return to the site until autumn, when an independent power supply for the ozone equipment was installed.



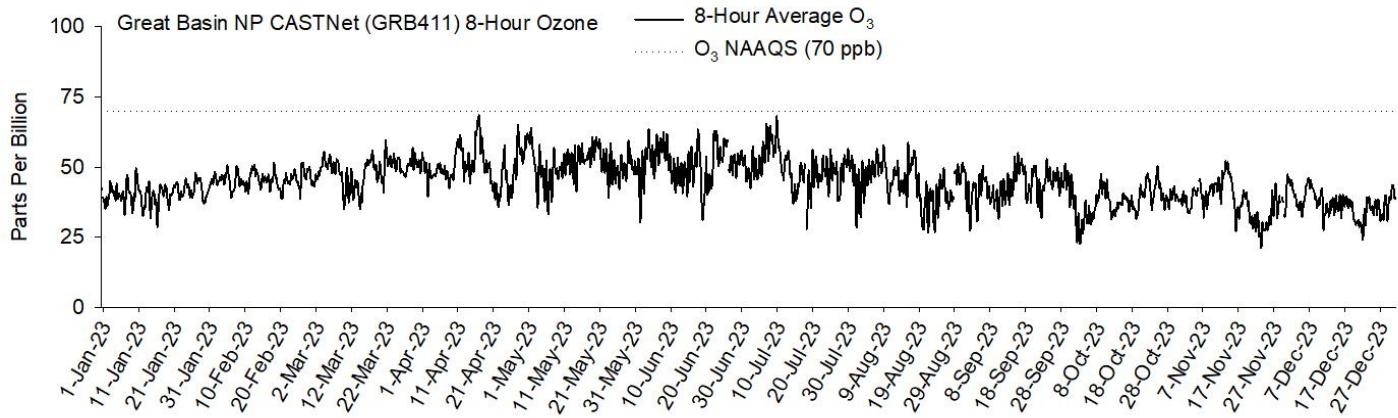
The positioning of the site is such that little solar power is available in the winter months, and only a brief period of valid data was collected. It is expected that better performance will result when the SNOTEL is repositioned in summer of 20204.

25. *Ruby Guard*. Instruments were installed on schedule in late March at Ruby Guard—after digging the site's enclosure out from 1.5m of snow—but another storm re-buried the site shortly thereafter, and data collection did not resume until early April. A full season of data collection then ensued, documenting the network's lowest ozone impact. The highest 8-hour average was only 62.4 ppb (April 16th), and fourth-max was 60.7 ppb (May 2nd), continuing a record of well-below-NAAQS figures. No elevated ozone events of significant length occurred in 2023.



Lowest on the network, the 3-month W126 peaked at only 7.4 ppm-hr (May-July). No vegetation hazard exists for the aspen, cercocarpus, or limber pine populations on the northeastern aspect of the surrounding Ruby Mountains.

26. *Great Basin NP CASTNet*. Ozone exceeded 70 ppb at Great Basin for a total of four hours on three occasions in 2023, and no 8-hour figures exceeded the threshold. The design value of 65.5 ppb (July 7th) and current three-year average of 65.2 ppb are well below NAAQS. All three-year figures since 2012-2014 have also been below NAAQS. No long periods of elevated ozone occurred.



Exposure (peak W126 of 11.2, May-July) was low and fairly typical of historical figures from this remote location.